Supergen
Offshore Renewable Energy

ORE Outlook 2040

UK Offshore Renewable Energy in 2040: Building a Sustainable and Competitive ORE Sector on a Pathway to Net Zero by 2050

A report by the Supergen ORE Hub (October 2024)

UKRI
Engineering and Physical Sciences Research Council

The Supergen ORE Hub is a £16.5 million Engineering and Physical Sciences Research Council (EPSRC) programme, 2018–2027, which brings together academia, industry, policymakers and the general public to support and accelerate the development of offshore wind, wave and tidal technology for the benefit of society.

The activities of the Supergen ORE Hub support everyone in the ORE journey to Net Zero and delivery of a just energy transition.

The Supergen ORE Hub provides sustained research leadership and connects stakeholders across the ORE sector to build collaboration, nationally and internationally.

Our research is helping to reduce design uncertainty in ORE, improve performance, learn from data, and find new ways to plan, build and operate ORE facilities.

Our research is signposting the pathway to a just transition by improving our understanding of ocean interactions and optimising ORE solutions for social and economic value.

The Supergen ORE Hub trains future leaders and aligns stakeholders through education, by promoting ORE and ocean literacy at all levels, by advocating for ORE with evidence for policy decision-making and by promoting a holistic whole-system approach to energy.

We continue to expand our partnerships and knowledge transfer to enable developers and suppliers to bring new technologies into the market and address key industry pain points. Positioned as a trusted voice in the ORE sector, the Supergen ORE Hub has a vital role in coordinating the academic community and communicating the urgency of change.

Applying sensors to tidal turbine blades, University of Hull

www.supergen-ore.net

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Mocean Energy Blue X Wave Energy Converter

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Supergen Offshore Renewable Energy

The ORE Outlook 2040 report summarises the current and future contribution of Offshore Renewable Energy (ORE) to the 2050 Net Zero target, using 2040 as a key milestone on this journey.

Section 1: Climate change, Net Zero, and 2040

The first section of the report sets the scene by summarising current climate change impacts and our progress so far in the energy transition. It shows the ORE deployment pathways needed to reach Net Zero by 2050, using 2040 as a key milestone. The economic and social benefits of a just, sustainable and secure energy transition are set out.

Section 2: Implications

The second section highlights the implications of the ORE deployment levels required by 2040, which are explored through four lenses: (i) planning and consenting, (ii) people, (iii) supply chain and (iv) infrastructure and grid.

The analysis shows that the required ORE growth cannot be reached by upscaling current business-as-usual methods alone. Instead, research and innovation are required to transform the technology and practices of the ORE sector, as well as the role of the ORE sector in communities and our understanding of the impact of ORE in the ocean.

This report is a call to action for researchers, industry, policymakers, and the public.

This ORE Outlook 2040 report has been written by the Supergen Offshore Renewable Energy (ORE) Hub as the trusted voice of the wider UK offshore renewable energy community.

The Hub is led by the University of Plymouth and includes Co-Directors from the Universities of Aberdeen, Edinburgh, Exeter, Hull, Manchester, Oxford, Southampton, Strathclyde, and Warwick. The Supergen ORE Hub is one of three Supergen Hubs and two Supergen Networks+ created by the EPSRC to deliver strategic and coordinated research on Sustainable Power Generation and supply.

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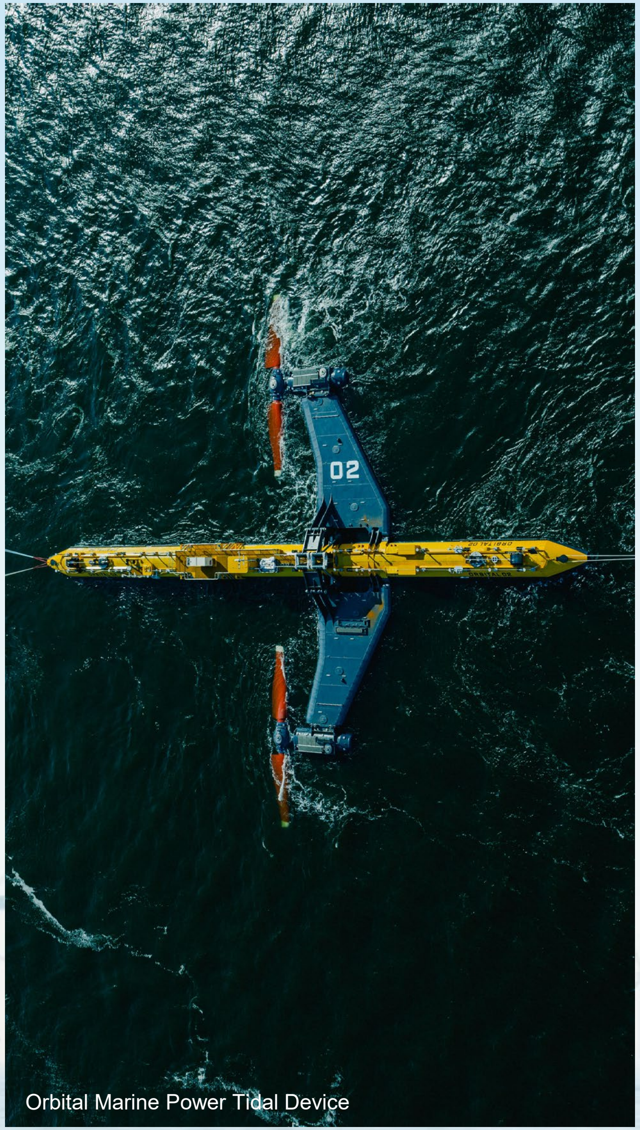


Orbital Marine Power Tidal Device

Section 1: Climate change, Net Zero and 2040

A summary of current climate change impacts and our progress so far in the energy transition.

Section 1: Climate change, Net Zero and 2040

Climate change: a growing global crisis

Climate change is having an increasing impact across the globe. Extreme weather is causing direct damage and loss, hampering food production, and affecting the habitability of many regions.

The growing effects of climate change will drive further population migration and intensify conflict for resources — food, energy and water — in an increasingly unproductive and uninhabitable world.

Net Zero by 2050: a global consensus

A global consensus was reached at the 2015 Paris Agreement: "To avert the climate crisis the global temperature increase should be limited to 1.5°C above pre-industrial levels … requiring greenhouse gas emissions to be reduced by 45% below 2010 levels by 2030 and reach Net Zero by 2050"[1].

Net Zero: environmental and economic sense

Climate action towards Net Zero is not a trade-off against economic development and growth[2]. The Paris Agreement target is also recognised as the economically-optimal pathway for this century[3].

Climate action unlocks wide economic benefits: not just by avoiding damage and loss, but by improving efficiency and productivity, health and biodiversity. However, successful climate action requires strong investment, clear policy support and societal change, to enable Net Zero and a Just Transition.

Net Zero: to secure the lives of the young

We are at a critical time in history; successful climate action to reach Net Zero is essential to secure the lives of today's young people[4].

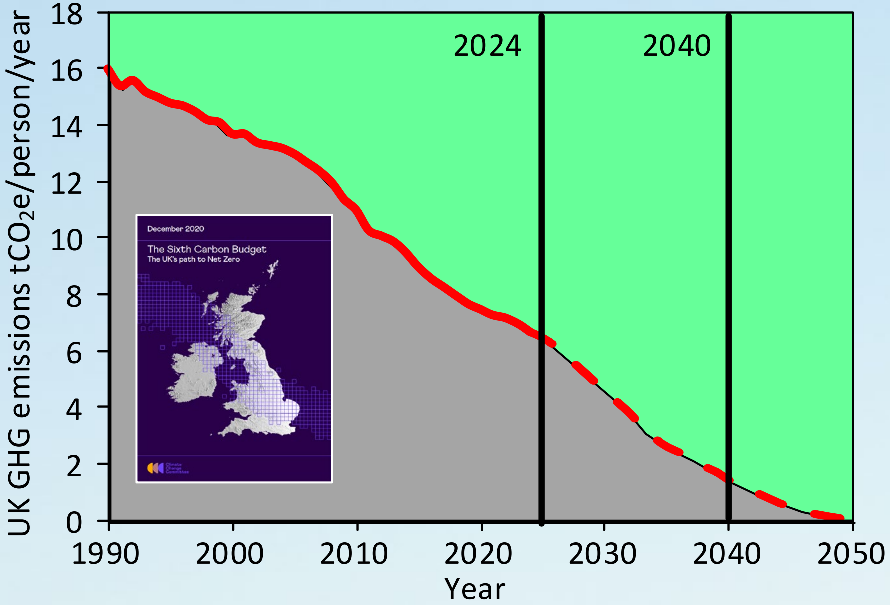


Figure 1. Progress in reducing UK greenhouse gas emissions and a future pathway to Net Zero by 2050 [5]

Climate impacts and barriers to action

Climate change impacts are both global and local

Global impacts: current examples

Loss of lives, homes, livelihoods and biodiversity from extreme weather, drought and lost food production[4]

UK impacts: current examples

Food price inflation of 5%/year[7]. Transport disruption due to climate impacts on earthworks[8].

Emissions cause deaths

Each 4,500 tCO_2e of emissions will cause one death this century[6].

4.500 tCO2e is produced by burning 10,000 barrels of oil, or by 3 full flights from London to Sydney.

Fossil fuels are falsely priced

Their supply costs neglect wider societal costs [2] and they are subsidised[9], slowing climate action (explicit global subsidy: US$1300B, UK subsidy: US$18.5B in 2022[9])

Net Zero: early progress driven by technology

Since 1990, greenhouse gas emissions in the UK have been cut by half (Fig. 1). Research and innovation have played a key role by reducing the cost of new technologies such as wind and solar power, to replace fossil-fuel usage. The price of offshore wind has fallen by a factor of three in the past decade[10]. This is a far higher rate than expected only a decade ago, and faster than other supply-side technologies.

2040: A key milestone towards Net Zero 2050

Looking ahead, 2040 is a valuable focus point. It is more relevant to current decision-making and more visible to stakeholders than 2050. However, 2040 is far enough ahead that policy decisions and new research and innovation can have a transformational impact on the ORE sector at that time.

The growth of the ORE sector and the changes to our energy system set out in this report must happen in the next 16 years, and far exceed even the rapid progress of the past 16 years, since 2008.

Achieving Net Zero by 2050 is crucial for a safe and prosperous future.

This report sets 2040 as a critical milestone on this journey and shows that research and innovation are vital for developing new technologies and driving rapid decarbonisation.

Net Zero – reducing the mountain to climb

2050 Net Zero

Delivering Net Zero

To deliver on the global consensus for Net Zero by 2050, the UK Climate Change Committee[5] sets out scenarios and pathways as a series of carbon budgets and targets for renewable energy and decarbonisation along the way.

However, a just transition away from fossil fuels requires changes across our entire energy system and the energy usage patterns, which is a complex system challenge that requires coordination of policy, finance, innovation, planning and social acceptance.

Like climbing an uncharted mountain

This challenge of achieving Net Zero can be represented as scaling an uncharted mountain. With business as usual, it is too steep a mountain to climb, there are insufficient resources, infrastructure, supply chain and workforce. Timescales for project development are too long, and if the UK's just transition to Net Zero by 2050 can be accelerated by one year, a total of 236 $MtCO_2e$ will be saved.[11]

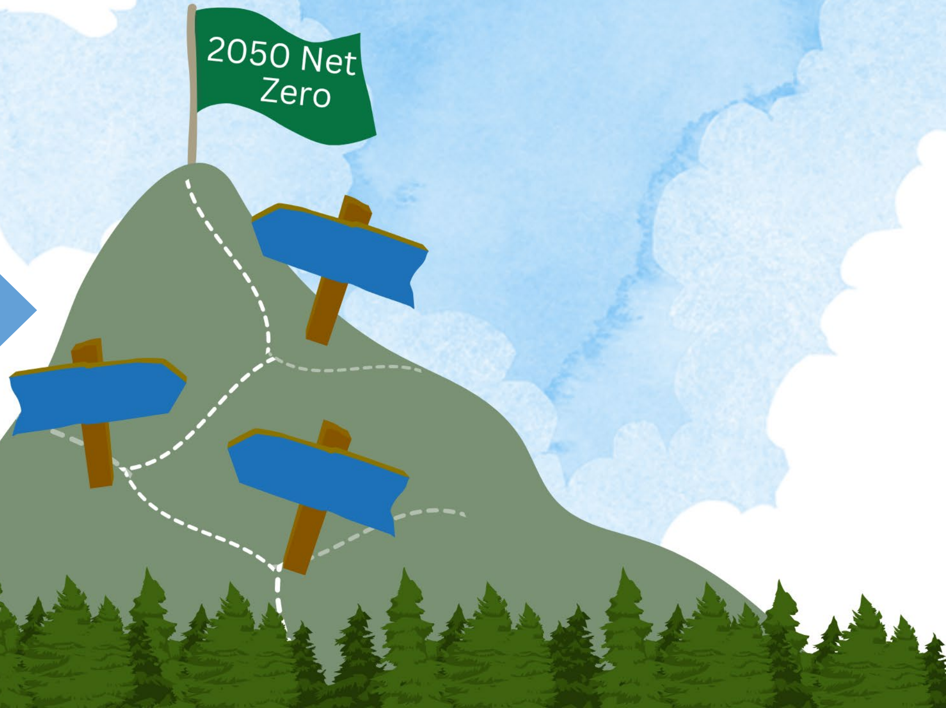
It is imperative to do things differently, to take a step change approach to accelerate the ORE sector and enable it to play its role as the backbone of our future energy system.

Research and Innovation are vital to achieving Net Zero by 2050

Research and innovation accelerate progress by de-risking new technology, reducing costs, providing crucial insight and building a skilled workforce.

We can reach the Net Zero summit by leveraging research and innovation to reduce the scale of the task, provide new knowledge and signpost the best route.

With Research and Innovation, we can reduce the scale of the Net Zero challenge and signpost the best route



Net Zero – finding the best route to climb the mountain

Just

Justice in the energy transition has many facets[12]. A just transition aims to address sources of unfairness and maximise the benefits for all. If the transition is unjust, support for climate action is reduced, diminishing the chance of reaching Net Zero.

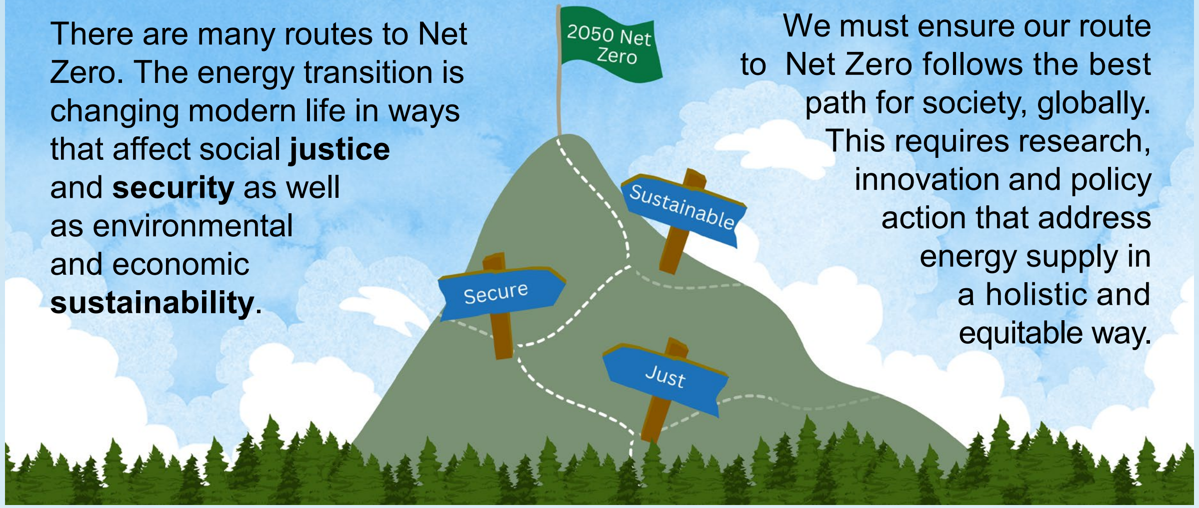
Social justice aims to ensure that the opportunities and benefits from Net Zero are distributed fairly and compensate people impacted negatively. For example, by investing in regions where fossil fuel activity is declining, to replace lost jobs[13, 14].

Net Zero tackles the growing harm to humanity and the environment caused by carbon emitters. **Climate justice** aims for fair compensation and help for regions that are disproportionately harmed by climate change relative to their historic emissions. **Environmental justice** aims to secure equitable protection from the environmental and health impacts of climate change, such as flooding, wildfires and pollution and aims for equitable access to environmental decision-making processes for all of society.

Policy action can create a 'pull' towards a just transition[15,16] and legal action can apply a 'push'[17,18], driving change in industry and governments. Action is often led by youth, who seek **intergenerational justice**[19].

Signposting a **just**, **secure** & **sustainable** Net Zero

There are many routes to Net Zero. The energy transition is changing modern life in ways that affect social **justice** and **security** as well as environmental and economic **sustainability**.



We must ensure our route to Net Zero follows the best path for society, globally. This requires research, innovation and policy action that address energy supply in a holistic and equitable way.

Sustainable

An energy transition that is sustainable uses ocean space responsibly, alongside the other ocean functions and usages. A sustainable ORE sector needs a resilient supply of inputs, from raw materials to project finance, and must minimise harmful outputs.

Environmental Sustainability: ORE growth must be managed to avoid triggering a critical material supply crisis, or associated growth in waste pollution. Sustainable sourcing of materials with efficient design and minimal wastage at end-of-life outcomes is essential[20].

Ocean Sustainability: ORE growth raises interactions with other ocean activity and marine ecology, which must be understood, managed and monitored to allow co-location of activities, protect biodiversity and optimise shared ocean usage[21].

Economic and Social Sustainability: An economically sustainable ORE sector requires long term project pipelines supported by appropriate policy, planning and financing mechanisms, to attract investment and reap benefits for workers and society [22].

Secure

Locally-generated ORE improves energy security by reducing the influence of **geopolitical instability** in supply chains linked to **fossil fuel production**[23].

However, **ORE infrastructure** can be far offshore and under remote control, making it **vulnerable to physical or cyber-attacks**[24].

Securing a Net Zero energy system underpinned by ORE requires greater capacity for energy storage and dispatch to balance the variability of offshore renewable energy. Also, the growing reliance on offshore infrastructure requires new monitoring and protection systems, for security and reliability.

There are many routes towards Net Zero.

We must follow a route that is just, secure, and sustainable to maximise both the benefits and achievability of Net Zero.

Currently 14 GW offshore wind

The UK has approximately 14.7 GW of offshore wind capacity currently installed[25]. The first project was commissioned in 2000, and installed capacity passed 1 GW in 2010, 5 GW in 2015, and 10 GW in 2020.

Target of 60 GW by 2030

The UK Government has an ambitious 2030 target of 60 GW of offshore wind, including 5 GW of floating capacity. There is currently a pipeline of 12 GW under construction or with a Contract for Difference (CfD)[26] in place, plus a further 21 GW in development and 47 GW in pre-planning of future projects [27].

The Future Energy Scenarios (FES) published by National Grid ESO[28] present pathways for the energy system to meet Net Zero by 2050, The FES Net Zero pathways for offshore wind growth indicate 44 GW of capacity by 2030, which is close to the previous UK Government target of 50 GW by 2030 but has a shortfall of 16 GW relative to the current 60 GW target.

100 GW by 2040 and 120 GW by 2050?

All FES pathways involve around 100 GW of offshore wind connected to the grid by 2040 (Fig. 2). Offshore wind growth slows beyond 2040 in the FES pathways, reaching 115–124 GW by the time Net Zero is reached in 2050.

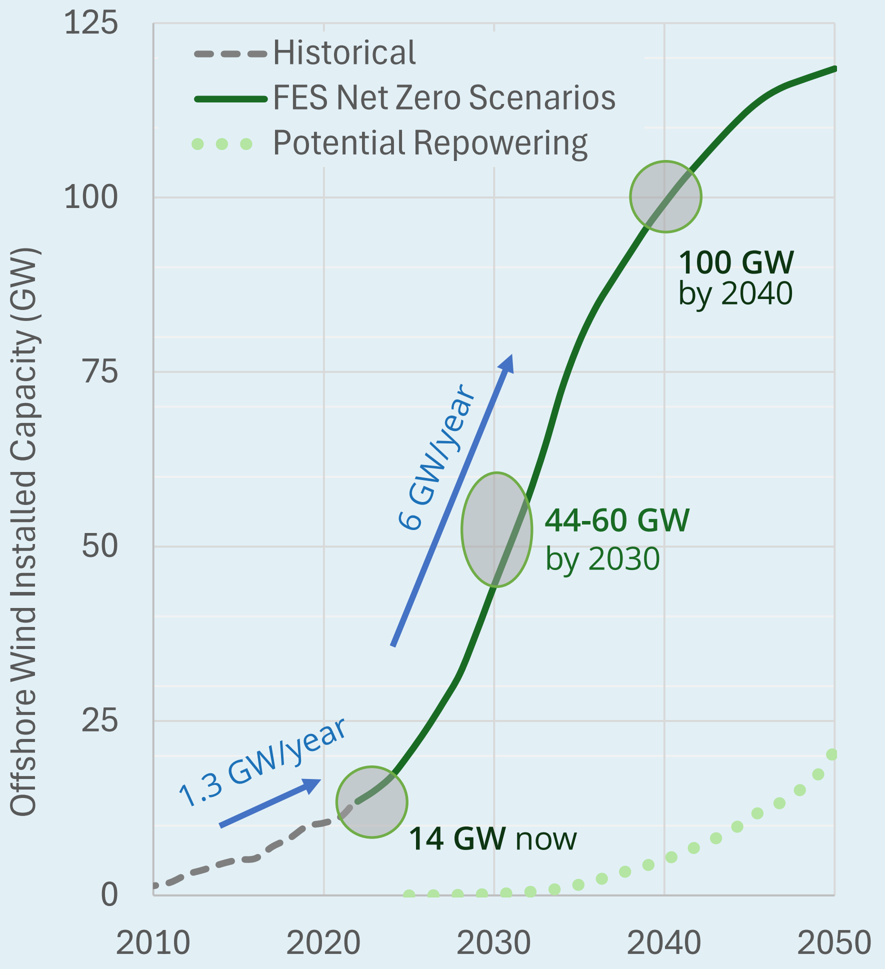
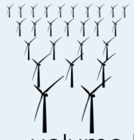


Figure 2. Historical and future pathways for the deployment of offshore wind connected to the GB grid to deliver Net Zero (data sources [28,29])

Upscaling needs solutions…

The UK has ramped up annual offshore wind deployment rates to approximately 1.3 GW/year over the past few years [28]. The ambitious pathway of **100 GW by 2040 is** almost **7× the current commissioned capacity**. To meet this growth, we will need to increase the installation rate by **4× the recent rate**, to around 6 GW per year (Fig. 2).

100 GW of offshore wind by 2040
Business-as-usual alone cannot achieve this level of upscaling



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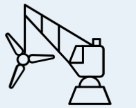
volume by 2040



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rate to 2040

…and technical innovation

Beyond 2030, floating offshore wind is likely to make up more than half of the offshore wind projects constructed. However, floating offshore wind technology is still undergoing rapid and significant innovation with 108 competing concepts being identified in recent reviews[30,31].

Repowering of offshore wind farms, shown as the dotted green line in Figure 2, will be necessary as turbines reach the end of their design life, usually 25 years. This repowering activity, in parallel to capacity growth, increases the scale of development required, compounding the challenge.

2040 ORE Deployment Levels: Tidal Stream

Tidal stream capacity is rapidly accelerating along a similar trajectory to offshore wind.

The UK is currently a global leader in developing tidal stream technology and has significant resource [32,34].

Studies have shown the practical UK tidal stream resource to be around 11 GW[32,33]. This spans a wide range of locations around our coast, although the UK resource is concentrated at only a few large sites.

An Energy Systems Modelling Environment (ESME) projection run by the Energy Systems Catapult (ESC)[35], which assumes that tidal stream meets the European 2030 SET Plan[35] targets, indicates that by 2050 the UK could deploy **6.2 GW tidal stream**.

Tidal Stream Roadmap

The UK Government does not yet have specific policy targets for tidal stream capacity. The Marine Energy Council have proposed a target of 1 GW by 2035[36] and the ORE Catapult's Roadmap for Tidal Stream [37] provides datasets for projection to 2040 assuming a similar pathway to reach 6 GW by 2050.

Figure 3 illustrates the UK tidal stream projects built to date and those planned with CfD in place. It also shows two future development pathways following ORE Catapult scenarios based on differing levels of policy support[38], with the slower rate scenario continued at linear growth to reach 6 GW by 2050. These pathways require deployment rates of 0.5 – 1 GW/year to be reached by 2040.

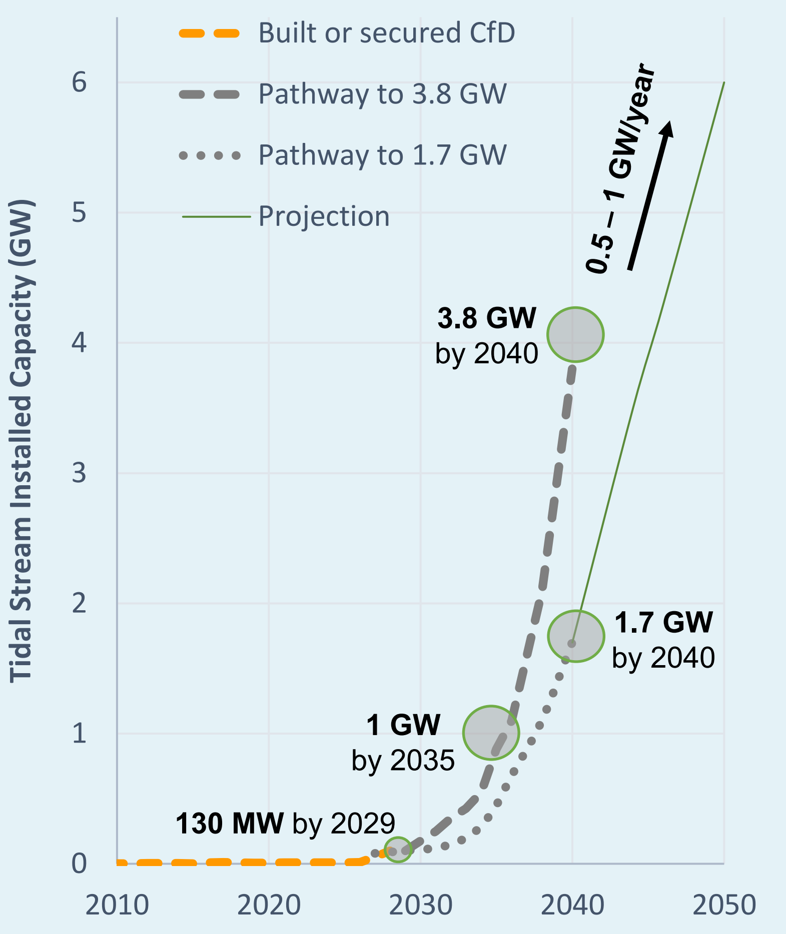

Figure 3. *Projected pathways for the deployment of tidal stream based on sector growth scenarios* [37, 38]

Tidal stream deployment pipeline

There is now a pipeline of tidal stream projects ready to be built, with 21 projects totalling 122 MW recently awarded market support funding under the CfD scheme [38,39,40]. These projects are all due to be commissioned between 2026 and 2029.

This amounts to a total of 83 MW for Scotland and 38 MW in Wales of contracted tidal stream capacity through the UK's renewable auctions, located at:

- MeyGen, Pentland Firth (59 MW)
- Morlais, North Wales (38 MW)
- EMEC Fall of Warness, Orkney (25 MW)

Other tidal stream projects are already consented, or are in the process of obtaining these, and two EU-funded tidal demonstration farms totalling 13.6 MW are also ongoing, at the EMEC site in Orkney [39].

SIMEC Atlantis Energy – MeyGen tidal project

2040 ORE Deployment Levels: Wave energy

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Wave energy has the potential for similar growth

Global deployment of wave energy is currently low, but it could follow a similar growth path to offshore wind.

The UK is currently a leader in developing wave energy technologies and has significant resource [33,34]. We should unlock this extra renewable energy source.

Assuming that wave energy meets the European 2030 SET Plan [35] targets, the ESC's ESME [40] modelling projects that **6.4 GW of wave energy** could be deployed by 2050 in the UK.

Untapped potential for wave energy

Wave energy is not yet at the stage of commercial deployment, but many countries around the world, including the UK, have huge wave energy resources and are actively developing technology and projects.

There is potential therefore for rapid deployment of wave energy technologies that are now being proven in demonstration projects [34]. The UK's exploitable wave energy resource is estimated to be approximately 25 GW [33].

There are other applications where wave energy is being actively explored, for example, to decarbonise offshore oil and gas operations, to provide renewable energy to small islands and remote communities, to power ocean buoys and aquaculture farms, and to provide remote recharging of autonomous ocean vehicles[46].

Wave energy scheme co-located with wind power (CorPower Ocean)

Wind/wave co-location opportunity

Studies have also shown potential cost savings and better use of ocean space by co-locating wave energy within offshore wind arrays [47, 63].

Wind-wave co-location can be achieved either by utilising the space between floating offshore wind structures or by developing hybrid wind-wave platforms. With wind turbines becoming taller and the space between them getting larger, WECs can be positioned to use this ocean space. By sharing infrastructure – such as power cables and sub-stations – and operation and maintenance services, both wind and wave energy can benefit from cost reductions.

The increasing size of wind turbines leads to the corresponding growth of the floating support structures. This also brings the opportunity to share supply chain commonalities with a platform for multiple WECs, leading to cost savings. The sharing of power distribution from wind and wave reduces variability and provides a higher base load to the grid.[47].

Additional UK benefits from wave and tidal

Given the UK's global leadership of tidal stream and wave energy, including UK-based design and manufacturing capacity, wave and tidal stream developments have high local content. The resultant Gross Value Added (GVA) to the UK economy by 2050 from the projected deployments would be up to £8.8bn, with a further £32bn from exports [41].

There are additional power systems benefits from tidal stream and wave energy resource being available at different times to other renewable generation technologies. These have been estimated as a £1.03bn reduction in annual dispatch costs, from a higher dispatch of renewable energy (up to 27 TWh, +6%), and thus a lower requirement for expensive peak period generation (by as much as 24 TWh, -16%) [42].

Over 12 GW of tidal stream and wave energy capacity is projected to be installed in the UK by 2050, equating to 10% of offshore wind capacity.

The UK currently leads the world in wave and tidal technology development, projected to add £40bn GVA to the UK economy and reduce energy balancing costs by £1bn/year.

Section 2: Implications of 2040 ORE Deployment Levels

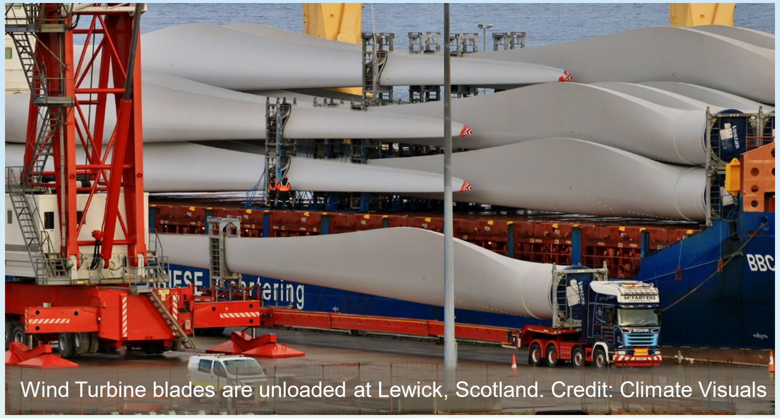
Highlighting the implications of the ORE deployment levels required by 2040.

Section 2: Implications of 2040 ORE Deployment Levels

Achieving the ORE deployment levels outlined in Section 1 has significant implications for the sector.

Section 2 of this report covers the implications for the wider ORE sector, focusing on:

People	Radical changes are required to expand and upskill the workforce and raise their productivity, to deliver the required ORE growth.	**Page 13**
Planning and Consenting	These processes must be made faster and more holistic, harnessing new technology and adaptive management.	**Page 14**
Infrastructure and Grid	Rapid action is needed to reconfigure our ORE infrastructure and our energy grid system, to accommodate faster ORE growth.	**Page 15**
Supply Chain	Investment in research and innovation is needed to transform ORE technologies and underpin supply chain competitiveness.	**Page 16**



Wind Turbine blades are unloaded at Lewick, Scotland. Credit: Climate Visuals

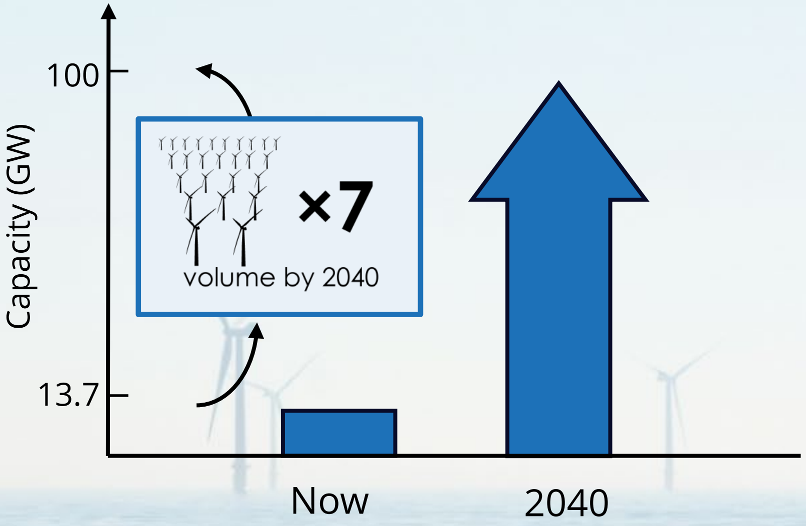


Figure 4. Forecast increase in offshore wind capacity

Sector workforce is growing

The Offshore Wind Industry Council (OWIC) publish annual Skills Intelligence Reports. These show the sector workforce grew from 26,000 to 32,000 in 2 years to 2022 (Fig. 5) [48,49,50].

Faster growth needed: workforce must triple by 2030

ORE growth will only occur if the workforce can deliver it. OWIC forecasts show that over 100,000 offshore wind jobs are needed by 2030[48]. This estimate already accounts for predicted increases in industry productivity and technology improvements[50] that improve safety and reduce the workforce requirement. However, if the current workforce trend is followed, it will result in only 58,000 jobs by 2030, a shortfall of 42,000. Faster training and recruitment of new personnel into the offshore renewables sector is needed.

Continued growth to 2040: six times more jobs

Extrapolating this workforce trend to 2040, reflecting the growing ORE deployments, suggests nearly 200,000 jobs will be required in UK offshore wind. This sixfold workforce growth will create new jobs that provide an opportunity to strengthen the social justice of the energy transition. On the current recruitment trend, only half the required workforce will exist.

Sector already stretched for people

This workforce expansion is not just needed in the UK, as the massive growth of the offshore wind market is happening around the world. China overtook the UK in deployed capacity in 2021 and in the US and Europe, plans are accelerating and ambitious growth targets set for the coming decades [51]. The growing market for tidal stream and wave energy will compound this workforce challenge as these sectors develop.

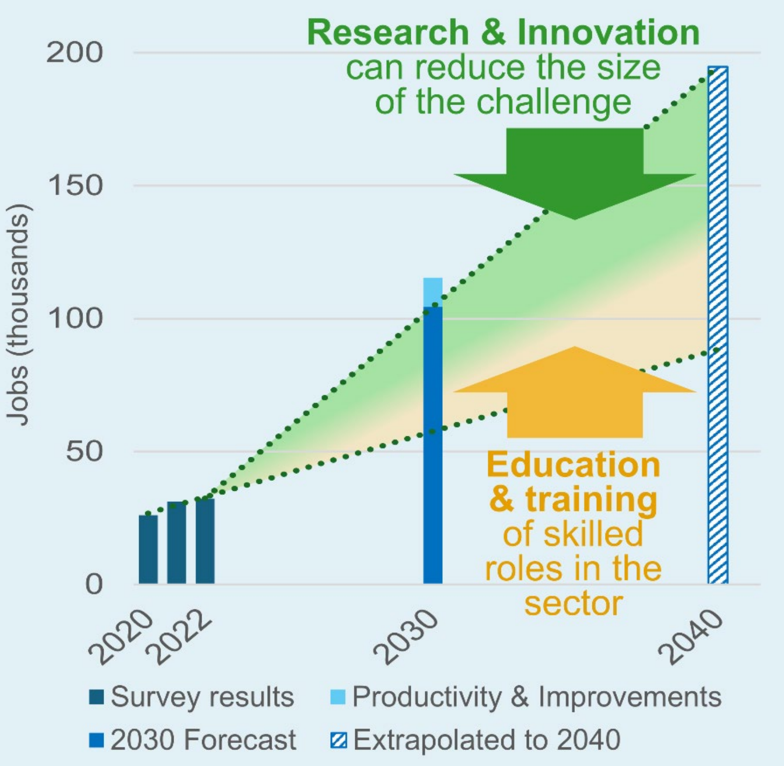


Figure 5. Jobs growth in ORE required by 2040 [43,44,45]

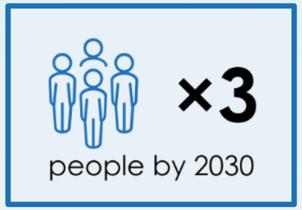
Research and Innovation to empower the workforce

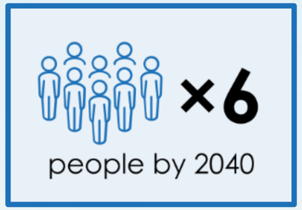
Research and Innovation can reduce the scale of the workforce challenge, for example through new technologies, such as AI, sensing, remotely operated vehicles or robotic systems for data collection, inspection and monitoring. These new approaches can improve the efficiency of workers and save time and cost. They can also increase safety with fewer people working offshore, and reduced carbon emissions [52,53,54].

Skills

Growing the sector workforce will provide opportunities for careers across a range of skill levels and disciplines. There is a need to invest in education and training to create the workforce and develop their skills.

We need to inspire the next generation towards careers in ORE and help to upskill or retrain mid-career employees, including offering a just energy transition for workers in fossil fuel industries. A growing pipeline of highly skilled ORE professionals is required, with expertise that includes areas of research and innovation that can improve efficiency and productivity while reducing costs and risks [55].





Business-as-usual alone will not meet the projected workforce requirements.

Research and innovation will boost productivity and improve safety offshore. This will be supported by targeted education and training to meet the remaining workforce gap.

2040 Outlook: Planning and Consenting

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Leasing to operation now takes about 15 years for UK wind farms

After securing a UK seabed lease for an ORE project there are several multi-year phases of project development (Fig. 6). The phases now take around 12 years until the Final Investment Decision (FID) is made and about 15 years to full operation[56,57,10].

The planning and consenting process ensures that new ORE projects will co-exist responsibly in the ocean environment, beside the marine ecosystem, maritime cultural heritage and existing human activity such as shipping, fishing, aquaculture, defence, mining and other uses (Fig. 7)[58].

Climate change harms ocean ecosystems, so any impact from ORE on the ocean is balanced by the contribution of ORE to Net Zero, climate action and ocean health[59,60]. Rapid decarbonisation, which requires ORE growth, is the key action for ocean health[75].

The need for speed in consenting…

The 2022 British Energy Security Strategy [57] aims to accelerate the planning and consenting process, stating the government would cut the time by over half, by "reducing consent time from up to four years down to one year" and "establishing a fast-track consenting route for priority cases". In 2024, GB Energy announced it will bring forward new offshore wind developments [61].

The British Energy Security Strategy aims to reduce consenting time to 1 year [52]

Data sharing is essential for rapid learning from current projects to help plan future deployments and reduce duplication of effort. Adaptive management methods, new technology and scenario modelling will also enable faster ORE deployments without compromising on net environmental impacts.

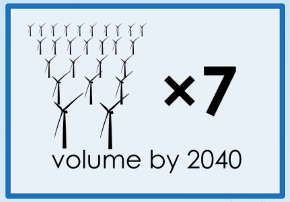
… and the tools and techniques to help

Faster planning and consenting processes need to be achieved concurrently with the 4× growth in the deployment rate required to meet the 2040 targets.

Innovation in robotics and remote and autonomous systems for data collection along with AI tools for analysis will help reduce the time and cost of survey data collection for environmental impact assessment (EIA).

Simultaneous sensing for EIA, resource data and for ongoing inspection will help optimise the use of data collection resources and the value of surveys and instrumentation.

Shared use of infrastructure through hybrid systems and co-location of technologies or activities in the same ocean space will enable both efficient use of resources and faster resolution of conflicts [62,63].



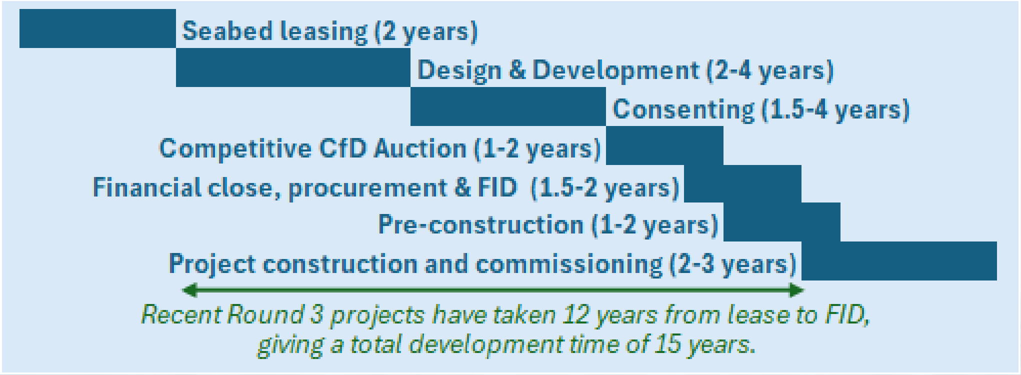


Figure 6. UK offshore wind farm development timeline. Adapted from [56,57,10]

The current timeline to build UK offshore renewables projects is too slow to meet Net Zero targets.

Planning and consenting processes can be accelerated through research and innovation, with better data, new insights and adaptive management

Figure 7. UK waters showing zones assigned to anthropogenic (human-related) use (e.g. ORE, cable and shipping routes, military zones, oil and gas, aggregate mining)[58]

2040 Outlook: Infrastructure and Grid

Port infrastructure upgrades

Offshore wind turbines are getting bigger. In 2015, the typical capacity of new turbines was 5 MW, with 100 m diameter rotors[58]. By 2030, it is expected that turbines of 300 m in diameter rated at 20 MW will be available[]. Larger turbines, and the move to floating foundations, requires much larger and upgraded port facilities. New quayside laydown space is needed for turbine towers, blades, nacelles, foundations, moorings and anchors, plus near-shore wet storage for floating foundations.

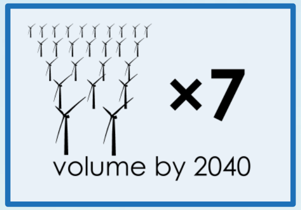
Ports need enlarging and adapting with bearing capacity to support components weighing hundreds of tonnes. Harbours need to be large enough to transport these giant turbines, with sufficient water depth by the quay, and clearance during tow-out[65, 66]. Research and innovation can inspire smaller or modular ORE elements to reduce infrastructure requirements[31, 74].

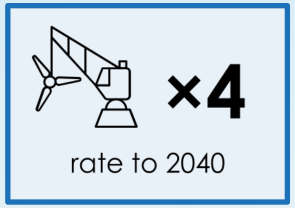
Infrastructure projects take up to a decade to build: port developments starting now will only operate by 2030[64].

CGI image for illustrative purposes only courtesy of Associated British Ports.

Decade-long lead times for building major infrastructure and overhauling the electricity grid means we must act now to meet 2040 requirements.

Research and innovation can reduce the infrastructure challenge – by easing requirements and accelerating timelines.





Further port facilities are required to support ongoing operations and maintenance (O&M) of offshore wind, as well as tidal stream and wave energy projects, all with differing requirements. Tidal stream and wave energy projects can often use smaller ports, given the smaller size of devices and projects, but the capacity needed could be comparable to current offshore wind needs by 2040[67, 68].

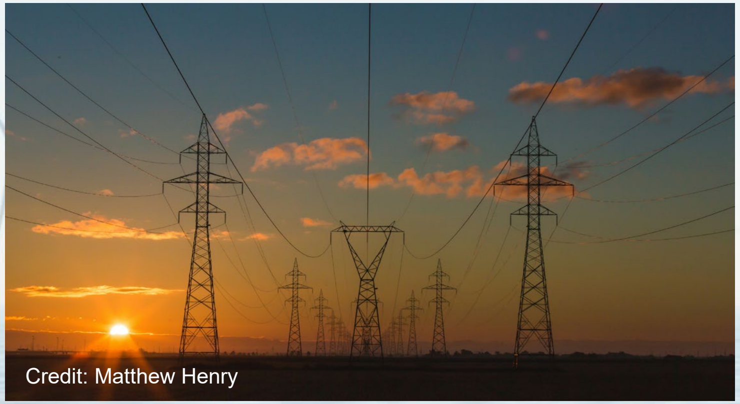
Lack of port capacity was highlighted in the recent report by the UK Government's Offshore Wind Champion[10]. There is an urgent need for investment. A recent study by the Floating Offshore Wind Taskforce suggests up to 13 port upgrades are needed, at an estimated cost of £4 billion [69]. The Offshore Wind Industrial Growth Plan identified a need to invest in 39 ports across the UK [70].

Electricity grid overhaul

The UK's current peak electricity demand is 58 GW and is forecasted to increase[71]. There is a growing queue of new energy supply and storage projects to be added to the grid. The UK's backlog for grid connections is the longest in Europe. Developers could be waiting up to 15 years to connect, and the queue is estimated to be stalling £15 billion worth of investment in offshore wind [69].

The National Grid's Holistic Network Design is an integrated approach for future offshore generation for 2030. It aims to provide a recommended offshore and onshore design for a 2030 electricity network, that facilitates the Government's ambition for offshore wind growth and a Net Zero grid by 2030[72].

The urgent need to upgrade the National Grid for a world of high renewables penetration and widespread electrification of homes and businesses was also highlighted as a key message from the Government's Offshore Wind Champion after reviewing the sector.[10].



Credit: Matthew Henry

2040 Outlook: Supply Chain

The supply chain challenge is a key bottleneck

The scale of the required ORE build-out is vast. To reach 100 GW of offshore wind capacity by 2050 could require more than 5,000 new turbines, assuming 17 MW capacity, taking the total in UK waters to almost 8,000.

More than half of the new offshore wind turbines in UK waters are likely to be on floating foundations secured by mooring systems. Scaling from Celtic Sea estimates[73], this could mean around 3,000 km of mooring line, over 8,000 km of electrical cables, and 10,000 anchors. Many hundreds of additional vessels will also be needed: for turbine transhipment, cable laying, anchor handling, plus ongoing services for operation and maintenance.

The UK supply chain will simultaneously need to support the deployment of tidal stream and wave energy projects, as well as the repowering of existing offshore wind. While wave and tidal stream share some commonality with offshore wind, they have unique requirements, and a high proportion of their supply chains are UK-based.[32, 34]

Hand sanding a wind turbine blade. Image courtesy of Climate Visuals

Research and innovation support the supply chain challenges…

Research and innovation can support the UK supply chain in a wide range of areas. Examples include innovations in new materials, manufacturing techniques, design concepts and analysis tools that make ORE systems easier and cheaper to build and install, and new tools for monitoring and maintaining ORE systems that make operations more efficient and reliable.

Through these advances, research and innovation raise the competitiveness and productivity of the UK supply chain, enabling higher local content in UK ORE projects, stronger export opportunities, and a faster and more just energy transition in the UK and globally.

Investment in research and innovation is crucial to underpin economic growth and supply chain competitiveness, securing UK economic content and technological leadership in the global ORE industry.

New Frontiers: Celtic Sea and ScotWind examples

The development of floating offshore wind in the Celtic Sea and in Scottish waters is an exciting opportunity for clean electricity production in parts of the UK that have not previously seen ORE developments of such scale. The Celtic Sea Blueprint [73] suggests that the 4.5 GW programme will lead to £1.4 billion GVA and an average of 5,300 jobs through the development of port infrastructure and critical component supply chain.

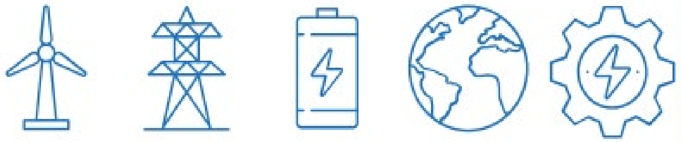
…and underpins the UK's ambition to be a global technology leader in offshore renewables

The Offshore Wind Industrial Growth Plan (IGP), was produced by the ORE sector in 2024 and identifies the need for commercial stakeholders to work with the Supergen ORE Hub to bring **new technologies to the market** and **address industry innovation priorities** [64].

Stronger investment in research, development and demonstration of ORE technologies will provide the UK with a competitive edge in key aspects of the supply chain and allow projects to raise their local content and create additional positive economic and social impact.

The IGP uses a make-or-buy priority assessment to identify areas in which the UK should invest and aim to be a global technology leader. Investment in these five key areas would lead to a tripling of manufacturing capacity and a doubling of research and development investment and output.

The UK aims to be a **global technology leader** in:



- Advanced Turbine Technology
- Industrialised Foundations & Substructures
- Future Electrical Systems & Cables
- Smart Environmental Services
- Next Generation Installation and O&M

2040 Outlook: Industrial Growth Plan

The Supergen ORE Hub supports the UK's ambition to be a **global technology leader**, outlined in the **Industrial Growth Plan**, with research in:

Advanced Turbine Technology

Including: turbine blade materials; recycling and lower cost manufacturing; development of digital twins for powertrain condition monitoring; and design for resilient onshore and support infrastructure.

Industrialised Foundations and Substructures

Future ORE scenarios, upscaling and circular economy; optimising design of fixed foundations and floating systems (anchors and moorings); modelling tools across scales; machine learning for rapid fatigue assessments, noise and corrosion control.

Future Electrical Systems and Cables

Risk-based design; insulation reliability under wave action; cable scour; water tree formation in dynamic cables; smart materials for partial discharge monitoring.

Smart Environmental Services

Array energy yield predictions combining physical processes and ecosystems for array planning and scale up; data-driven streamlining of ORE project planning, design and development.

Next Generation Installation, Operations and Maintenance

Structural health monitoring of future ORE systems; risk-based design; marine autonomous robots for offshore wind farm inspection; machine learning to integrate metocean data, sensor networks, and model output.

The UK's Offshore Wind Industrial Growth Plan (IGP) was produced in 2024 by RenewableUK, the Offshore Wind Industry Council, The Crown Estate and Crown Estate Scotland, following consultation across the sector, including with the Supergen ORE Hub. The IGP provides a shared vision that enables industry, Governments across the UK and other funders to better align their investments to boost green jobs and manufacturing in the UK.

https://www.renewableuk.com/media/rqvlqzu0/offshore-wind-industrial-growth-plan.pdf

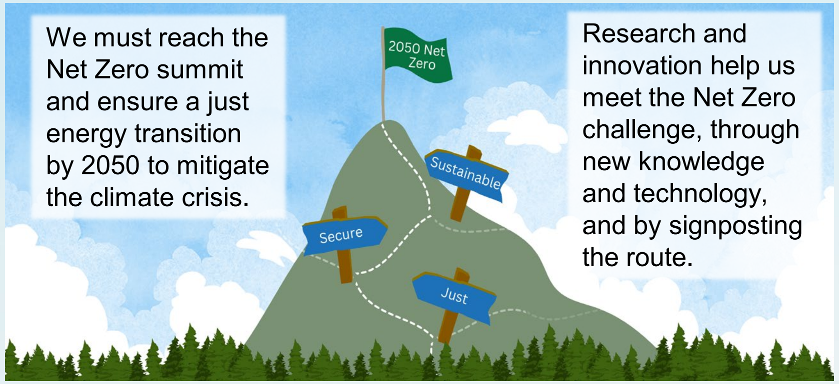
Summary: Research and Innovation to enable ORE Growth

This ORE Outlook 2040 report presents the current state and future trajectory of UK ORE, underpinned by an evidence basis that includes a wide range of peer-reviewed research.

Rapid ORE growth is essential to achieve Net Zero by 2050 and mitigate the climate crisis. Climate change and global heating are already affecting daily life in the UK and globally and are an existential threat to humanity. Rapid ORE growth is also a driver of economic and social wellbeing, supporting a just energy transition for all of society.

The ORE Outlook 2040 report shows that Research and Innovation are vital to enable the required ORE growth. A step-change in policy and action, underpinned by research and innovation, supported by the Supergen ORE Hub, will solve the challenges to ORE Growth across (i) people, (ii) planning and consenting, (iii) infrastructure and grid and (iv) supply chain. Research and innovation accelerate progress by developing new technologies, reducing costs, providing knowledge and insight for policy, and building the workforce.

This report is a call to action from the Supergen ORE Hub. Researchers, industry, policymakers, and the public can engage with us at https://supergen-ore.net



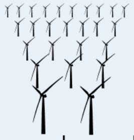
The ORE Outlook 2040 summarises the scale of the UK ORE growth required by 2040 using three simple measures, scaled relative to today:

(i) The volume of ORE capacity by 2040

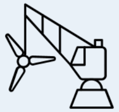
(ii) The rate of building ORE from now to 2040

(iii) The ORE sector workforce size by 2040.

These multipliers show we must act urgently.



×7
volume by 2040



×4
rate to 2040

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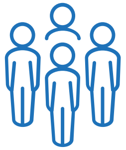
people by 2040

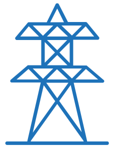


People

The current rate of sector workforce growth will not meet the projected requirements. Research and Innovation can reduce the scale of the workforce challenge by boosting productivity and can also protect safety offshore. The ORE community must inspire the next generation into ORE careers and provide targeted education and training to upskill and reskill people into the ORE workforce.

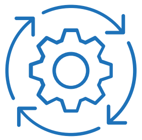
Planning and consenting

The current timeline to build UK offshore renewables projects is too slow to meet Net Zero targets, taking up to 15 years from leasing to operation. Planning and consenting processes can be accelerated through Research and Innovation, by enabling new data gathering and sharing methods, adaptive management, and by providing new knowledge and insights into ocean interactions.



Infrastructure and grid

Decade-long lead times for building major infrastructure and overhauling the electricity grid means we must act now to meet 2040 requirements. Research and Innovation can reduce the infrastructure challenge by easing requirements – for example through smaller or modular ORE components – and by accelerating timelines with efficient planning and construction.



Supply chain

Investment in Research and Innovation is crucial to supply chain competitiveness. A strong supply chain will secure UK economic content and technological leadership in the global ORE industry, resulting in a faster and more just energy transition in the UK and globally. The Offshore Wind Industrial Growth Plan (IGP) provides a shared vision for the UK ORE sector.

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University of Hull researcher inspecting a tidal turbine blade. Credit: University of Hull

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Mocean Energy Blue X Wave Energy Converter. Credit: Mocean Energy

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Orbital Marine Power Tidal Device. Credit: Orbital Marine Power

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Mountain image depicting how research and innovation we can reduce the scale of the Net Zero challenge. Credit: Supergen ORE Hub

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Mountain image and signposts for the best route to Net Zero. Credit: Supergen ORE Hub

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MeyGen Tidal Project. Courtesy of SIMEC Atlantis Energy.

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Computer Generated Image (CGI) illustrating plans for commercial scale Wave Energy Converters. Credit: CorPower Ocean

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Blades are unloaded at Lewick, Scotland. Credit: Ronnie Robertson / Climate Visuals

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Electricity pylons. Credit: Matthew Henry on Unsplash

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Man wearing a filtering mask, sanding by hand a large wind turbine blade in a factory. Credit: Joan Sullivan / Climate Visuals

Front cover of 2024 Offshore Wind Industrial Growth Plan.

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Mountain image and signposts for the best route to Net Zero. Credit: Supergen ORE Hub

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Fixed offshore wind farm. Credit: Nicholas Doherty on Unsplash

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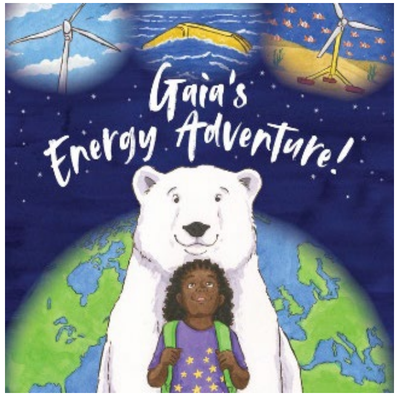


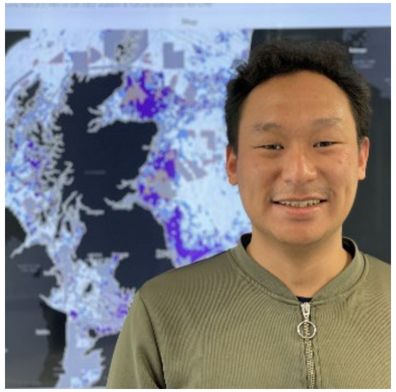


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